The mechanism of learning effect of online courses in higher-education: An explanation based on the interactive distance theory

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Abstract: "Online courses" avoid the limitation of time and space and effectively integrate educational resources by using internet technology, thus accelerating the development of modern education. The wide use of online courses since the COVID-19 pandemic has made the learning effect of online courses and its influencing factors attract the attention of educators and educational researchers. Based on the Transactional Distance Theory, this paper constructed a model of factors influencing the learning effect of online courses in higher education. We collected sample data of 743 participants in online courses and evaluated the learning effect of online courses through structural equations. The results show that: (1) material content utility and interaction utility of online courses have a significant positive effect on the learning effect and course satisfaction evaluation; further, attention has a mediating effect on the learning effect; (2) Compared with "live broadcast" courses, the effect of material content and interaction on learning effect is stronger in "live broadcast + recording" courses; (3) differences in students' characteristics result in different learning effects. The conclusion of this study provides a theoretical basis for improving the learning effect of online teaching and a reference for formulating targeted incentive strategies based on students' characteristics.

1. Introduction

Since the beginning of the COVID-19 pandemic in 2020, the Chinese government has adopted the "classes suspended, but learning continues" policy to promote the popularization of online courses. According to the 48th Statistical Report on Internet Development in China, the number of online education users in China reached 325 million in June 2021. In the first half of 2020, 282 million students nationwide switched to online courses under the guidance and boost of the aforementioned policy, further improving education informatization. However, while online courses expanded the scope of education [1], there is constant controversy over their effectiveness. Huang

(2020) argued that online courses only copy schools' teaching model and lacks innovation[1]. Online teaching is no different from offline teaching. So, what about the performance of online courses and the factors that affect performance? Does performance have a different output based on the student? We attempted to answer these questions in our study.

There are three main research areas on online courses: First, the development of hybrid online and offline teaching. This type of research explores the integration of online and offline courses [2], including the effective combination of online courses and traditional teaching methods. The development of information technology makes online teaching an alternative teaching mode and platform. It also realizes the construction of a diversified environment for online and offline hybrid teaching [3, 4]. Second, exploratory study on online courses. This type of research focuses on the use of courses, such as students' online course use duration and other relevant information without supervision [5]. Teachers' demonstration effect, a learning community, and a learning support mechanism play an important role in learning effectiveness [6]. Pande and Mythili's (2021) found that academic counselling provided by MOOCs（Massive open online courses）to students is conceptual, clear, and knowledgeable [7]. However, this type of research is descriptive statistics and lacks relevant research on learning effect and learning behaviour. The third type of research is constructing and exploring MOOC, SPOC, and other courses. They proposed MOOC as a place for students to access through an online system and can be accessed anytime and anywhere.

In general, there is a lack of existing studies on the effectiveness of online courses. Further, the studies on individual students are mainly descriptive and lack the support of data model verification results. Therefore, this study focuses on the factors influencing learning in online courses in higher education and discusses the influencing mechanism of courses and students' characteristics.

2. Theory and hypothesis

2.1. Transactional Distance Theory

Moore (1972) proposed two main concepts of distance education: Distance teaching and student autonomy [8]. Moore incorporated these two concepts when developing the "Transactional Distance Theory." He believed that "distance is a teaching phenomenon" [9]. Distance education has various constantly changing learning environments [10]. On this basis, Moore defined transactional distance as the "psychological and communication space" between students and teachers [11]. Moore stated that the development of interactivity of teachers and students is influenced by three basic factors: (1) Dialogue between teachers and students. Here, dialogue refers to the degree of communication and response between students and teachers, using interviews, video conferences, social software, electronic materials, and other auxiliary tools; (2) Flexibility of course structure. That is, the flexibility of course structure design, course auxiliary materials, and teaching content arrangement [12,13]; (3) The degree of students' autonomy in the learning process.

In network teaching or face-to-face teaching, there is a distance in the interaction of students and teachers. The "distance" here refers to the communication distance between teachers and students. Online education is a type of distance education because teachers and students are separated by geographical distance, making it easier to have a distance in understanding and cognition. This phenomenon needs to be overcome by the interaction mechanism of teacher, student, and web to reduce the transactional distance and produce positive and effective interactive effects. All types of learning theories, such as cooperative learning and social learning theories, have emphasized the importance of interaction. Moore's Transactional Distance Theory provides a basic framework for studying distance online education.

2.2. Foundation of Hypotheses

2.2.1. The material content utility of online courses and the learning effect

In information-based education, the dynamic, sustainable, and open learning resources are emphasized [14]. The requirement of higher education for students is the cultivation of professional and practical abilities [15]. Holmberg (2005) posited that well-designed learning materials could help enhance the feelings between students and teachers, thus improving the learning effect [16]. The material content utility of online courses includes text, audio, images, videos, etc. The material content utility of online courses is also closely related to course satisfaction, thus affecting students' learning effect. The content quality of online courses refers to the characteristic indexes that can meet online learners' learning and communication needs in higher education and conform to the course content, internet media content, and network information resource content. Therefore, the following hypotheses are proposed in this study:

H1: The material content utility of online courses has a significant positive impact on students' course satisfaction, attention and learning effect.

2.2.2. The interaction utility of online courses and the learning effect

Interactive learning is experiences based on real-life. It involves interaction and communication between students and teachers, and among students, allowing the students to develop their critical thinking. The key to online course success is meaningful interaction between students and teachers [17]. Moore's Transactional Distance Theory points out that distance educators need to achieve three types of interaction in the teaching process: (1) student-content, (2) student-teacher, and (3) student-student [18]. First, student-content interaction is the key feature of the success of distance education. It is a process of intellectual interaction with content, which will lead to a change in students' understanding and cognitive structure [19]. Second, student-teacher interaction is also a priority in online education, determining whether teachers' teaching objectives match students' expectations. Teachers improve students' self-awareness through motivation, but different students respond differently to the same motivation. Therefore, to achieve a good match between teaching objectives and students' expectations, it is necessary for teachers to constantly understand students' motivation and adjust teaching strategies during the interaction. When exploring the interaction between teachers and students, Liu and Zhang (2017) found that if teachers have enough control and practical experience to achieve good interaction with students, students' learning effect can be effectively improved [20]. In the absence of teacher support, students have a limited ability to understand the learning material [21], which may negatively impact subsequent learning processes [22]. Third, student-student interaction is also an important dimension of interaction. Students can communicate with each other individually or in groups. In this paper, we adopted Moore's Transactional Distance Theory, and proposed the following hypotheses:

H2: The interaction utility of online courses has a significant positive impact on students' course satisfaction, attention and learning effect.

2.2.3. The online course satisfaction, attention and learning effect

The factors that influence learners' satisfaction with online courses are flexibility and quality, perceived usefulness, ease of use, and diversification of evaluation [23]. Researchers found no difference between age and gender in students' satisfaction evaluation of online courses [24], and the differences in grade and major category can also be ignored [25]. Previous studies found differences in students' evaluation of online courses' duration and teaching style [26]. Students' learning effect is largely determined by their learning behaviour [26]. When students are more

satisfied, they pay more attention [27].

Lack of attention will directly lead to problems in reading and learning [28]. Xia et al. (2020) found that among the factors affecting the effect of online learning during the epidemic, the learner dimension included six sub-variables: learning attitude, class attendance rate, learning environment, attention, self-control, and homework quality [29]. According to the results, attention was an effective indicator of improving the quality of students' online learning. Good attention was the foundation of good learning quality. Risko et al. (2013) believed that students' learning effect was influenced by their continuous concentration on learning content [30]. Therefore, hypotheses are as following:

H3-1: Students' course satisfaction and attention play a mediating role in the relationship between material content utility, interaction utility, and learning effect.

H3-2: Students' course satisfaction and attention play a chain of multiple mediating roles among material content utility, interaction utility, and learning effect.

2.3. Study Design and Data Analysis

2.3.1. Data collection and pre-processing

Table 1: Descriptive statistics of samples (n=743)

Variables	Levels	Frequency	Percentage (%)
Gender	male	317	42.66
	female	426	57.34
Grade	First-year student	516	69.45
	sophomore	98	13.19
	junior	118	15.88
	senior	11	1.48
Professional attributes	liberal art	490	65.95
	science departments	253	34.05
Temperament type	phlegmatic temperament	207	27.86
	choleric temperament	38	5.11
	melancholic temperament	59	7.94
	sanguineous temperament	89	11.98
	mixed temperament	350	47.11

This study used a questionnaire to collect data. The questionnaire is divided into three parts. The first part is basic information, including school, major, grade, online learning experience, teaching type, gender, and age. The second part is the measurement scale of material content utility, interaction utility, and attention of online courses. Among them, the material content utility is measured with four dimensions: satisfaction degree, usefulness, richness, and practicability of material content. Interaction utility is measured with five dimensions: interaction participation, interaction usefulness with teachers, interaction usefulness with classmates, interaction usefulness between three parties, and interaction attention. Attention is measured with three dimensions: concentration, doing things unrelated to class, and doing things related to the class. The measurement item of course satisfaction is "In general, I am satisfied with online courses." The learning effect was measured as "I learn efficiently when taking online courses." All items in the second part were measured on a 5-point Likert scale (1=strongly disagree, 5=strongly agree). Moreover, Moore (1972) believed that the effect of distance education was affected by students' personality traits [8]. Therefore, the third part of the questionnaire was the participants' personality traits test item. In this study, temperament type was used to distinguish personality traits, and the

temperament type scale was used to measure the personality traits.

The survey was conducted from March 10, 2020, to April 1, 2020. Students from 16 universities in China, including Hangzhou, Harbin, Changchun, Beijing, Shanghai, Xuzhou, Nanjing and Changsha, were surveyed. A total of 1,014 students completed the questionnaire, and 778 valid questionnaires were collected, with an effective rate of 76.73%. After deleting the questionnaires with incomplete information and controlling for the feature of "online learning experience," 743 valid sample data were obtained. The specific descriptive statistics of samples are shown in Table 1.

2.3.2. Hypothesis verification

Main effect verification

Table 2 shows descriptive statistical indicators and correlation coefficient matrix of all relevant variables.

Table 2: Descriptive statistics of variables (n=743)

Var	Max	Min	Mean	SD	1	2	3	4	5
Material content utility	5	1.50	3.79	.80	1				
Interaction utility	5	1.29	3.64	.85	.69**	1			
Attention	5	1	3.56	.71	.53**	.42**	1		
Course satisfaction	5	1	3.63	1.08	.71**	.55**	.54**	1	
Learning effect	5	1	3.28	1.08	.66**	.59**	.50**	.74**	1

** Significant correlation was found at.01 level (bilateral).

Table 3: Verification results of multiple linear regression model (n=743)

	M1 DV: Course satisfaction		M2 DV: Attention		M3 DV: Learning effect	
	β	p	β	p	β	p
Material content utility	0.62	0.00	0.46	0.00	0.48	0.00
Course satisfaction	0.13	0.00	0.10	0.02	0.26	0.00
R^2	0.51		0.29		0.47	
AdjustedR^2	0.51		0.29		0.47	
F	381.17		149.80		325.82	
Sig.	0.00		0.00		0.00	

**Significant correlation was found at.01 level (bilateral).

The main effect was verified by multiple regression analysis using SPSS26.0 (Table 3). Material content utility and interaction utility are independent variables (IV) in all three models (M1, M2, M3). Course satisfaction, attention, and learning effect were dependent variables (DV). The results show that material content utility has a significant positive impact on course satisfaction, attention, and learning effect. Thus, hypotheses H1 were verified. Interaction utility has a significant positive impact on course satisfaction, attention, and learning effect. Therefore, research hypotheses H2 were also verified.

Mediation effect verification

The model has multiple parallel mediating variables, and the independent variables are continuous. Therefore, the Bootstrap method in SPSS26.0 was adopted in this study to conduct a complete mediating effect test. The data output results show that the total effect is significant (P =0.00), and the overall R^2 value of the model is 0.59>0.5, indicating a good fitting effect. Table 4 shows the effect analysis results of material content utility as the independent variable. The results

showed that the total mediating effect was statistically significant, and all paths in the indirect effect test were statistically significant.

Table 4: Mediation effect verification results (IV = Material content utility)

Effect	Path	Effect	SE	t	p	LLCI	ULCI
Direct Effect	Material content utility→ Learning effect	0.33	0.05	7.05	0.00	0.24	0.42
	Material content utility→ Course satisfaction	0.95	0.04	27.12	0.00	0.88	1.02
	Material content utility→ Attention	0.27	0.04	7.14	0.00	0.19	0.34
Indirect Effect	Course satisfaction→ Attention	0.21	0.03	7.70	0.00	0.16	0.27
	Course satisfaction→ Learning effect	0.51	0.04	14.76	0.00	0.44	0.58
	Attention→ Learning effect	0.15	0.04	3.41	0.00	0.06	0.24
Total Effect	Material content utility→ Learning effect	0.88	0.04	23.73	0.00	0.81	0.95

Note: LLCI refers to the lower limit of 95% interval of the estimate, and ULCI refers to the upper limit of 95% interval of the estimate

Table 5 shows the results of the indirect effect verification. In the mediation path of "material content utility→course satisfaction→learning effect," the 95% interval did not include the number 0 (95% CI: 0.39~0.44), indicating the existence of this mediation effect path. According to the mediation path of "material content utility→attention→learning effect", the 95% interval did does not include the number 0 (95% CI: 0.02-0.04), indicating the existence of this mediation effect path. In the chain mediation effect path analysis, "material content utility→course satisfaction→attention →learning effect," the 95% interval did not include the number 0 (95% CI:0.02~0.03), so this mediation effect path exists. Therefore, through verification, we found that "course satisfaction" and "attention" have separate mediating effects in the model and form multiple chain mediating effects. Therefore, hypothesis H3-1 was confirmed. Regarding the mediating effect test, the mediating effect was decomposed. The total mediating effect accounted for 0.56/0.88x100%≈63.00% of the total effect, indicating that 63.00% of the effect of the material content on the learning effect was influenced by the two mediating variables "course satisfaction" and "attention," and the mediating effect was larger than the direct effect.

Table 5: Indirect effect verification results (IV = Material content utility)

Path	Effect	Boot SE	BootLLCI	BootULCI	z	p
Material content utility→ Course satisfaction→ Learning effect	0.49	0.01	0.39	0.44	39.21	0.00
Material content utility→ Attention→ Learning effect	0.04	0.01	0.02	0.04	8.87	0.00
Material content utility→ Course satisfaction→ Attention→ Learning effect	0.03	0.00	0.02	0.03	8.57	0.00

Note: BootLLCI refers to the lower limit of 95% interval of Bootstrap sampling, and BootULCI refers to the upper limit of 95% interval of Bootstrap sampling; The bold part is chain intermediate, and the rest is parallel intermediate.

Mediating effect of interaction utility on learning effect

Table 6 shows the effect analysis results of interaction utility as the independent variable. The results show that the total mediating effect was statistically significant, and all paths in the indirect effect test were statistically significant.

Table 7 shows that in the mediation path of the "interaction utility→course satisfaction→learning effect," the 95% interval did not include the number 0 (95% CI: 0.28-0.36), indicating the existence of this mediation effect path. From the perspective of the mediation path of "interaction utility→attention→learning effect," the 95% interval also did not include the number 0 (95% CI: 0.01-0.03), indicating the existence of this mediation effect path. Chain mediation path analysis showed that the mediation path of "interaction utility→course

satisfaction→attention→learning effect" did not include the number 0 in the 95% interval (95% CI: 0.02-0.03), indicating the existence of the mediation effect path. Therefore, through verification, we found that "course satisfaction" and "attention" have separate mediating effects in the model, and form multiple chain mediating effects. Therefore, hypothesis H3-2 was confirmed. Regarding the mediation effect test, the mediation effect was decomposed. The total mediating effect accounted for 0.442/0.752x100%≈58.78% of the total effect, indicating that 58.78% of the effect of interaction utility on the learning effect is through the two mediating variables of "course satisfaction" and "attention," and the mediating effect is larger than the direct effect.

Table 6: Mediation effect verification results (IV = Interaction utility)

Effect	Path	Effect	SE	t	p	LLCI	ULCI
Direct Effect	Interaction utility→ Learning effect	0.31	0.04	8.55	0.00	0.24	0.38
	Interaction utility→ Course satisfaction	0.71	0.04	18.12	0.00	0.63	0.79
	Interaction utility→ Attention	0.15	0.03	4.74	0.00	0.09	0.21
Indirect Effect	Course satisfaction→ Attention	0.29	0.02	12.07	0.00	0.24	0.34
	Course satisfaction→ Learning effect	0.54	0.03	17.74	0.00	0.48	0.60
	Attention→ Learning effect	0.17	0.04	3.90	0.00	0.08	0.25
Total Effect	Interaction utility→ Learning effect	0.75	0.04	19.88	0.00	0.68	0.83

Table 7: Indirect effect verification results (IV = Interaction utility)

Path	Effect	Boot SE	BootLLCI	BootULCI	z	p
Interaction utility→Course satisfaction→Learning effect	0.38	0.02	0.28	0.36	21.15	0.00
Interaction utility→Attention→Learning effect	0.02	0.00	0.01	0.03	5.57	0.00
Interaction utility→Course satisfaction→Attention→Learning effect	0.03	0.00	0.02	0.03	11.75	0.00

3. Conclusions

Based on the Transactional Distance Theory (TDT), this study examines the factors that influence the learning effect in online courses. Using online courses in higher education as the research subject, this paper constructs the following relationship models: "Material content utility," "Interaction utility," "Course satisfaction," "Attention," and "Learning effect." The relationship between the related variables was verified through regression analysis and the structural equation method, and the corresponding research conclusions were obtained.

When "Material content utility" and "Interaction utility" are high, the Learning effect is relatively better. "Course satisfaction" and "Attention" have positive mediating effects on "Material content utility" and "Interaction utility" on the learning effect, and the mediating effect is greater than the direct effect. Therefore, in addition to material content utility and interaction utility, course satisfaction and attention are influencing conditions for the online learning effect.

There are differences in the learning effect and influencing mechanism among students with different temperament types. Students with choleric temperament had the best overall learning effect. Alternatively, the students with phlegmatic and mixed temperament types were more affected by "course satisfaction" and "attention;" these students had a worse learning effect. This finding can help students understand the advantages and disadvantages of online learning and reduce the adverse effects of harmful factors and habits.

Teachers should optimize the structure design and content arrangement of online courses to ensure the richness of course content. Online courses are in a closed learning environment. Compared with traditional courses, the course structure design should be more flexible and adjusted

according to the needs of students to ensure the timeliness, accuracy, and richness of courses. Based on the core knowledge structure, interesting and expanding auxiliary materials should be integrated to stimulate students' exploration consciousness and thirst for knowledge.

Acknowledgements

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